Investigating the association between renal tissue oxygenation and development of AKI in preterm neonates

Paige E. Condit[1], Jennifer E. Chuck[2], Michael R. Lasarev[3], Valerie Y. Chock[2], Matthew W. Harer[1]

Department of Pediatrics[1] and Biostatistics & Medical Informatics[3], University of Wisconsin School of Medicine and Public Health, Madison, WI

Division of Neonatal and Developmental Medicine[2], Stanford University School of Medicine, Palo Alto, CA

Background

- Neonatal acute kidney injury (AKI) is a frequent problem associated with short- and long-term consequences, with a range of estimated prevalence from 18%-48%.[1]
- AKI is defined by elevations in serum creatinine (SCr) and decreases in urine output[2], both difficult to measure in preterm neonates.
- Renal tissue oxygenation ($RrSO_2$) measured with with near-infrared spectroscopy (NIRS) is a noninvasive tool being used in NICUs to monitor kidney perfusion and function.
- Changes in NIRS values have been associated with development of AKI, however, the relationship between traditional markers of AKI and changes in $RrSO_2$ has not been well established.

Objective

The purpose of this study is to evaluate the relationship between $RrSO_2$ changes and SCr during the first week of age for preterm neonates born at < 32 weeks gestational age (GA).

Methods

Study Design

- Two-center (A & B) retrospective cohort study.
- Inclusion criteria: <32 weeks GA and NIRS sensors applied <48 hours of age.
- Exclusion criteria: No known congenital renal anomalies.

Study Intervention

- $RrSO_2$ was monitored via INVOS sensor placed over the left or right flank over Mepitel dressing.
- $RrSO_2$ values of 109 neonates were collected from the time INVOS sensor was placed until the infants were 7 days old.
- SCr values, patient and maternal demographics were obtained from the medical record.

Outcome

- AKI was determined by the modified neonatal Kidney Disease: Improving Global Outcomes (KDIGO) definition excluding urine output (UOP) due to concerns with accuracy of collection.

Statistics

- Variables were compared between groups of neonates with AKI vs neonates without AKI using rank-sum or exact unconditional tests for continuous and categorical variables, respectively.

KDIGO neonatal AKI definition

Stage	SCr	UOP
0	No change or rise < 0.3 mg/dL	>1 mL/kg/hr
1	Rise ≥ 0.3 mg/dL w/in 48 hrs or ≥ 1.5-1.9 x reference SCr w/in 7 days	>0.5 and ≤ 1 mL/kg/hr
2	Rise ≥ 2-2.9 x reference SCr	>0.3 and ≤ 0.5 mL/kg/hr
3	Rise ≥ 3x reference SCr or SCr ≥ 2.5 mg/dL or receipt of dialysis	≤ 0.3 mL/kg/hr

In this retrospective study, decreases in mean renal oxygenation measured by near-infrared spectroscopy in preterm neonates born at < 32 weeks GA were associated with an increased risk of AKI. Changes in renal oxygenation may allow for noninvasive detection of infants at risk for AKI.

@WiscPeds

Harer Research Group

Citations

[1] Jetton JG, Boohaker LJ, Sethi SK, Wazir S, Rohatgi S, Soranno DE, et al. Incidence and outcomes of neonatal acute kidney injury (AWAKEN): a multicentre, multinational, observational cohort study. Lancet Child Adolesc Health. 2017;1:184-94.

[2] Zappitelli M, Ambalavanan N, Askenazi DJ, Moxey-Mims MM, Kimmel PL, Star RA, et al. Developing a neonatal acute kidney injury research definition: a report from the NIDDK neonatal AKI workshop. Pediatr Res. 2017;82:569-73.

Results

- 109 neonates with 560 SCr values were included.
- 8 cases of AKI were present in the cohort with similar incidence between the two centers (9% at A and 7% at B, p=0.767).
- For the 8 cases with AKI, the median [IQR] of their mean %RrSO2 was 46.2 [32.8,70.5] and for the non-AKI cases it was 67.1 [58.5, 74.0] (p=0.12).

A decrease of 10 percentage points in mean %RrSO2 was associated with a 1.7-fold increase in AKI risk (95% CI: 1.1–2.6; p = 0.016).

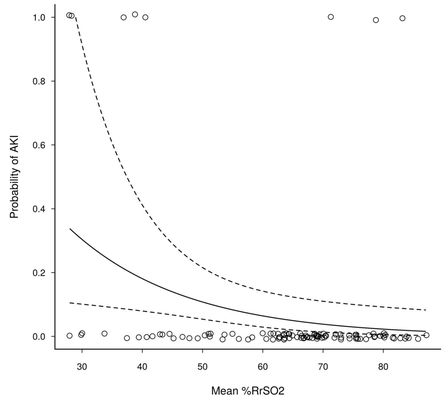

Figure 1: Association between mean $\%RrSO_2$ (horizontal axis) and probability of developing AKI (vertical axis). Individual mean $\%RrSO_2$ values are indicated by circular points for 8 infants who developed AKI (probability 1; top edge) and the other 101 who didn't (probability 0; bottom edge). Solid line shows increasing probability with decreasing mean $\%RrSO_2$ and 95% confidence interval as surrounding dashed lines.

Table 1: Demographics	AKI (n=8)	No AKI (n=101)
Gestational age (wks)	25.6 [23.8,27.1]	27.0 [25.7,28.7]
Birth weight (kgs)	0.74 [0.57,0.89]	0.92 [0.73,1.19]
Sex, Female	4 (50)	48 (48)
Apgar score at 5 minutes	7 [3,8]	7 [6,8]
Mean $\%RrSO_2$	46.2 [32.8,70.5]	67.1 [58.5, 74.0]
Mean SCr (mg/dL)	0.85 [0.72,0.99]	0.76 [0.67, 0.84]

Categorical data presented as number (percentage) and continuous data presented as median (interquartile range).

Conclusions

- Neonates with decreasing mean $RrSO_2$ had increased risk of developing AKI.
- This data suggests that detecting changes in $RrSO_2$ may allow for noninvasive identification of neonates at risk for AKI.
- Further prospective studies are necessary to determine whether $RrSO_2$ changes can accurately detect AKI.
- Future guidelines and studies should focus on early interventions and therapies that can improve kidney oxygenation and whether improved kidney oxygenation improves short- and long-term kidney outcomes.

Funding

UnityPoint Health Meriter Foundation

Department of Pediatrics, University of Wisconsin School of Medicine and Public Health

Acknowledgements: We would like to thank the patients and families from the Meriter UPH NICU and Lucile Packard Children's Hospital NICU

Disclosures: We have no financial or conflicts of interest

Contact Information: Paige E. Condit, Pediatrics Resident, UWSMPH, pcondit@uwhealth.org @ConditPaige